10. VARIATIONS IN THE ADDITION OF POLYPROPYLENE FIBER, FLY ASH AND IMMERSION IN ASPHALT MIXTURES ON STABILITY AND FLOW

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VARIATIONS IN THE ADDITION OF POLYPROPYLENE FIBER, FLY ASH AND IMMERSION IN ASPHALT MIXTURES ON STABILITY AND FLOW

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Road damage in Indonesia on average is caused by water. Water causes the binding capacity between asphalt and aggregate to decrease. Therefore, research is needed to improve the stability of the asphalt mixture by adding fillers such as Polypropylene fiber and Fly Ash with variations in immersion. In this study, the variation of Polypropylene fibers is 1%, 2%, 3% and 4% of the total aggregate. While the use of Fly Ash remains, at 6% of the total aggregate. To test the resistance to water, a 1 hour, 24 hours and 48 hours immersion is used. The results showed that Polypropylene fiber and Fly Ash can be used as fillers in asphalt mixtures because they meet filler characteristics and are able to improve stability and flow in the asphalt mixture. Variation of 2% Polypropylene fiber with a 24 hours immersion resulted in a stability value of 2004,97 kg. In the variation of 2% Polypropylene fiber with a 24 hours immersion produced a flow of 6,08 mm. Addition of 2% Polypropylene fiber with 24 hours immersion can increase stability by 17,18% and flow by 14.33%. At 2% addition of Polypropylene fiber and 24 hours immersion, optimum stability and flow are obtained.

Keywords: Polypropylene Fiber, Fly Ash, Stability, Flow, asphalt mixture.

1. INTRODUCTION

Most roads in Indonesia are flexible pavements that use asphalt as a binder. Asphalt strength is strongly influenced by water because water can reduce the binding capacity between asphalt and aggregate [1]. Many are found, road damage is caused by bad drainage so that the water pooled during the rainy season [2],[3]. When the asphalt bond and aggregate are loose due to water, the passing vehicle will give a burden that will damage the bond, and make cracks and holes arise [4]. The hole is getting bigger and bigger because it holds water and will damage the road foundation. Asphalt is also influenced by temperature, at high temperatures, the asphalt tends to soften, while in cold temperatures the asphalt becomes brittle [5],[6]. The vehicle load causes the deformation on the asphalt [7],[8]. Based on the description above, it is necessary to conduct research to improve the stability and flow of the asphalt mixture from the influence of temperature and water, using Polypropylene fiber and Fly Ash as additives. Characteristics of Polypropylene fiber are having a hydrophobic surface, which is resistant to water and shock loads [9]. While the characteristics of Fly Ash have a good binding ability, the size of the grain is very small so that it can fill the voids between the aggregates and is able to provide hydraulic effects. From the mixing of the two ingredients in the asphalt mixture, it can provide a flexible effect but is also resistant to water so that it can be an alternative to flexible pavement repairs.

2. LITERATURE REVIEW

Polypropylene fiber

Polypropylene fibers are fibers that resemble mesh-shaped fibers and have a diameter of 90 microns with a length of about 6 to 50 mm. Polypropylene fiber is the basic ingredient in making goods made of plastic. While this plastic is an object that is difficult to decompose so that it can cause waste to accumulate. The images of Polypropylene fiber are shown in figure 1 below:

Figure 1. Polypropylene fiber

Polypropylene fiber is a composite fiber that has hydrophobic properties or is resistant to water and has a high melting point of 165°C and will harden quickly when the temperature has dropped. By its nature, when mixed in asphalt mixtures, Polypropylene fiber will work optimally in supporting the resistance of the mixture to shock loads, to melting, the effect of shrinkage and being able to withstand bending moments due to dynamic loads acting on the surface of the mixture [10]. While the weakness in Polypropylene fiber lies in the lateral area where fiber is present. The characteristics of Polypropylene fiber are shown in table 1 below:

Table 1. Characteristics of Polypropylene Fiber

Characteristics	Polypropylene fiber
Form	Thin fiber mesh network
Fiber diameter	90 microns
Fiber length	19 mm
Specific gravity	0,9
Tensile strength	5600 kg/cm^2
Modulus of Elasticity	35000 kg/cm^2
Water Absorption	Nil
Melting point	170^{0}C
Concrete Surface	Haired

Fly Ash

Fly Ash is an inorganic material that comes from the remaining coal combustion and is formed from changes in mineral materials due to the combustion process. In coal burning in a power plant, two types are formed, namely Fly Ash and Bottom Ash. The ash particles carried by the exhaust gas are called Fly Ash, while the ash left and removed from under the furnace is called Bottom Ash. The advantages of Fly Ash when used as a mixture are strong adhesion because it contains silica and alumina with relatively low lime content [11],[12]. Fly Ash is ash like cement but in terms of colour, Fly Ash is darker than cement. Fly Ash itself does not have the binding ability as cement, but when mixing with water the silica oxide contained in Fly Ash will react with calcium hydroxide which can produce substances that have the ability to bind [13].

Marshall Test

The purpose of Marshall testing includes testing of flow, analysis of pore density, and mixture stability. From the Marshall test, it will be known how much the maximum load that can be received before the test material is destroyed (Marshall Stability) and also the amount of deformation that occurs from the specimen before finally being destroyed (Marshall Flow). Then the next Marshall test is the Marshall Immersion Test. In this experiment, the specimen is placed in a tub filled with water which is then left to stand for a minimum period of at least 30 minutes. This test aims to measure the amount of bonding strength of the effect of water and temperature (water sensitivity and temperature susceptibility). The Marshall test parameters aimed at identifying the properties of the asphalt mixture are as follows [14]:

1. Marshall Stability

Marshall Stability is a condition where the load shows the maximum value needed for the results of a press failure when testing a test object using the Marshall procedure. The boundary conditions for Marshall stability for heavy traffic conditions in Indonesia as determined by AASHTO are 1500 lbs or 680 kg, and 840 kg for British Standard.

2. Flow

Deformation that occurs during the initial loading to decrease the stability caused by the resistance to the running load received by the pavement.

3. METHODOLOGY

In this study, specimens will be used with a mixture of polypropylene fibers and fly ash as fillers with variations in immersion. The stages of research are:

1.) Determining the optimum bitumen content, the variations used are 4%; 4,5%; 5%; 5,5%; and 6%. In this experiment polypropylene fibers and fly ash were not used.

2.) In this study, fly ash was used for 6% of the total aggregate.

3.) Determine the optimum levels of polypropylene fibers with variations of 0%, 1%, 2%, 3% and 4%. Each variation consists of 3 specimens.

4.) Last immersion test was carried out to determine the strength of the asphalt mixture against temperature and water as in table 2.

Table 2. Experimental Design Model for Stability/Flow

Immersion	Polypropylene Fiber				
	0%	1%	2%	3%	4%
1 hour	3X	3X	3X	3X	3X
24 hours	3X	3X	3X	3X	3X
48 hours	3X	3X	3X	3X	3X

5.) In this study to determine the effect of variations in the addition of polypropylene fiber and immersion in the asphalt mixture on stability and flow used a two-way variance analysis. Hypothesis stated:

a. H_0^1 : $\alpha_1 = \alpha_2 = \ldots\ldots.. = \alpha_i$

H_1^1 : $\alpha_i > 0$

b. H_0^2 : $\beta_1 = \beta_2 = \ldots\ldots.. = \beta_j$

H_1^2 : $\beta_j > 0$

c. H_0^3 : $(\alpha\beta)_{12} = (\alpha\beta)_{22} = \ldots\ldots.. = (\alpha\beta)_{ij}$

H_1^3 : $(\alpha\beta)_{ij} > 0$

By : α = Variation in addition of Polypropylene fibers

β = Variation of immersion

H_0 = There is no influence between the two

H_1 = There is an influence between the two

After being analyzed, the calculated F_{value} will be compared with F_{table} with free degrees that correspond to certain α values. If the value of $F_{value} > F_{table}$ means H_0 is rejected and if the value of $F_{value} < F_{table}$ means H_0 is accepted

6.) Whereas to determine the relationship of the effect of variations in the addition of variations in the addition of polypropylene fibers and immersion on the asphalt mixture on stability and flow used two-way regression analysis.

4. DISCUSSION

Material testing carried out is on coarse aggregates and fine aggregates which aims to determine the properties and characteristics of the aggregate. In this study, Pertamina's 60/70 production asphalt penetration was used. In the preliminary experiment, an experiment was conducted to determine the optimum asphalt. For this experiment, Polypropylene fiber and Fly Ash were not added. The results of this experiment are as shown in table 3 below:

Table 3. Results of Calculation of Asphalt Characteristics

No.	Characteristics	Term	% of bitumen content against total aggregate				
			4	4,5	5	5,5	6
1	Stability (kg)	min. 800	1250,32	1034,82	1056,35	999,89	1074,68
2	Flow (mm)	min. 3	4,97	4,87	4,87	5,5	5,13
3	MQ (kg/mm)	min. 250	252,06	209,79	219,82	184,96	209,62

Source: Research results

Based on the table above, the optimum asphalt content used for this study is 5% of the total aggregate. The Marshall test sample was then made on the test object which had been immersion. The time variation used in the test immersion test specimens is immersion 1 hour, 24 hours, and 48 hours. While the filler levels tested at each immersion time have variations of 0%, 1%, 2%, 3% and 4% with each specimen 3 pieces. After immersion is carried out, the Marshall test is carried out on each specimen, so that the percentage value of the average character is obtained as shown in table 3 and table 4 below:

Table 3. Relationship of Polypropylene Fiber with Immersion Against Stability

No.	Immersion	Terms	Polypropylene Fiber				
			0%	1%	2%	3%	4%
1	1 hour	min. 800	1800	1808	1673	1221	1054
2	24 hours	min. 800	1703	1966	1997	1876	1590
3	48 hours	min. 800	1336	1091	1078	1036	1024

Source: Research results

Furthermore, statistical tests were carried out to determine the effect of variations in Polypropylene fiber addition and immersion on stability. From the hypothesis, get the results as in table 5.

Table 5. ANOVA Results

Source of Uniformity	db	Sum of Squares	Least Squares	F_{Value}	F_{table}
Poplypropylene Fiber (PF)	4	3834269,20	958567,3	47091,19	2,37
Immersion (I)	2	-38941064	-19470532	-956521,77	200
PF & I	8	40976192	5122024	251627,82	1,94
Error	45	916	20,36		
Total	59	5870313,2			

From the table above, it can be concluded that $F_{Value} > F_{Table}$ = 251627,82 > 1,94. This shows that H_0 is rejected and H_1 is accepted, meaning that Polypropylene fiber variations and immersion affect the stability of the asphalt mixture. To determine the relationship of Polypropylene fiber variation and immersion to stability expressed by the equation:

$$Y = 1831,14 + 0,82.X - 50,88.Z + 34,32.X.Z - 0,24.X^2 - 42,34.Z^2 - 5,44.X.Z^2$$

$-0{,}78.X^2.Z + 0{,}145.X^2.Z^2$

By : Y = Stability (kg)

X = Polypropylene Fiber Variation (%)

Z = Immersion (Hours)

$R^2 = 0{,}983$

$R = 0{,}979$

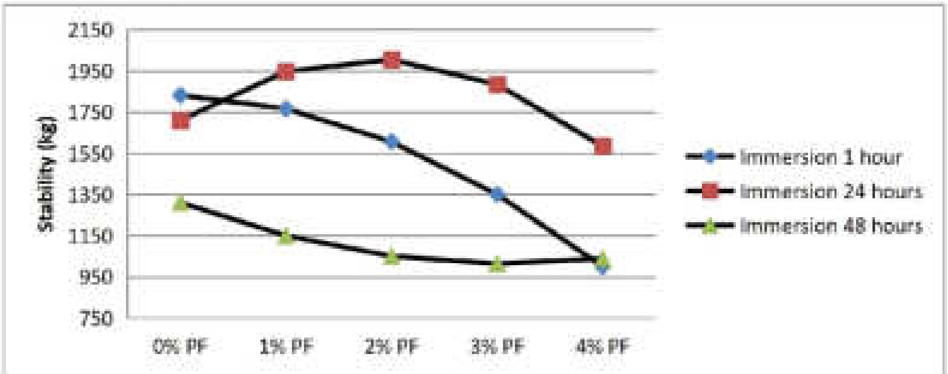

Figure 2. Graph of the Relationship of Polypropylene Fiber with Immersion Against Stability

From Figure 2 above, 2% of Polypropylene fiber content with 24 hours of immersion obtained optimum stability value. Addition of 2% Polypropylene fiber with 24 hours immersion can increase stability by 17,18%. Table 6 shows the results of flow experiments with variations in Polypropylene Fiber and Immersion.

Table 6. Average Flow Value

No.	Immersion	Terms	Polypropylene Fiber				
			0%	1%	2%	3%	4%
1	1 hour	min. 3	4,97	4,87	4,73	4,6	4,5
2	24 hours	min. 3	5,33	5,87	6,2	5,7	5,1
3	48 hours	min. 3	3,73	3,07	2,97	2,87	2,73

Source: Research results

Using Anova results are obtained as shown in table 7 below:

Table 7. Anova Results

Source of Uniformity	db	Sum of Squares	Least Squares	F_{Value}	F_{table}
Poplypropylene Fiber (PF)	4	50,8	12,70	293,10	2,37
Immersion (I)	2	-360,5	-180,25	-4159,58	200
PF & I	8	365,01	45,63	1052,93	1,94
Error	45	1,95	0,04		
Total	59	57,27			

From table 7, it is concluded that $F_{Value} > F_{Table} = 1052,93 > 1,94$. This shows that H_0 is rejected and H_1 is accepted, meaning that Polypropylene fiber variations and immersion affect Flow. The relationship between the three is expressed by the equation:

$$Y = 4,92 + 0,06.X - 0,22.Z + 0,09.X.Z - 0,002.X^2 + 0,02.Z^2 - 0,02.X.Z^2 - 0,002.X^2.Z + 0,0005.X^2.Z^2$$

By : Y = Flow (mm)

X = Polypropylene Fiber Variation (%)

Z = Immersion (Hours)

$R^2 = 0,962$

$R = 0,954$

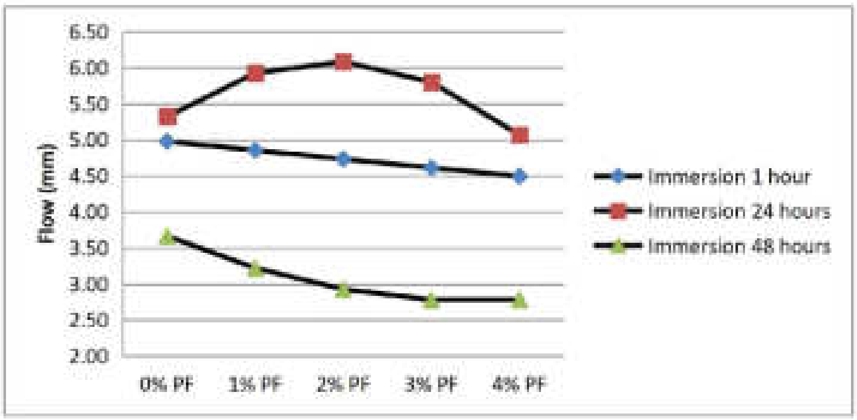

Figure 3. Graph of the Relationship of Polypropylene Fiber to Immersion Against Flow

Based on Figure 3, the variation of 2% Polypropylene fiber with 24 hours immersion obtained the optimum flow value of 6,08 mm. Addition of 2% Polypropylene fiber with 24 hours immersion can increase flow by 14,33%. Whereas other varieties of Polypropylene fiber, especially at 48 hours immersion, do not meet the requirements. This shows that immersion for 48 hours will damage the asphalt mixture because the binding capacity of the asphalt and aggregate is much reduced.

5. CONCLUSION

From the discussion above, conclusions can be drawn, including:

1. Polypropylene fiber and immersion affect stability and flow in the asphalt mixture.

2. Polypropylene fiber and Fly Ash can be used as fillers in asphalt mixtures. The addition of 2% Polypropylene fiber with 24 hours immersion can increase stability by 17,18% and flow by 14,33%.
3. The relationship of Polypropylene fiber variation and immersion to stability is expressed by the equation:

$$Y = 1831{,}14 + 0{,}82.X - 50{,}88.Z + 34{,}32.X.Z - 0{,}24.X^2 - 42{,}34.Z^2 - 5{,}44.X.Z^2 - 0{,}78.X^2.Z + 0{,}145.X^2.Z^2$$

4. The relationship of Polypropylene fiber variation and immersion to flow is expressed by the equation:

$$Y = 4{,}92 + 0{,}06.X - 0{,}22.Z + 0{,}09.X.Z - 0{,}002.X^2 + 0{,}02.Z^2 - 0{,}02.X.Z^2 - 0{,}002.X^2.Z + 0{,}0005.X^2.Z^2$$

5. Asphalt mixture using polypropylene fiber and fly ash has optimal strength values at 24 hours immersion time and then decreases at 48 hours immersion time. This indicates that the durability of the mixture will tend to decrease towards the longer immersion time.

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